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THE MIGRATORY LOCUST IN ENGLAND IN 1946

By B. P. Uvarov, C.M.G., D.Sc., F.R.E.S.
(*Anti-Locust Research Centre.*)

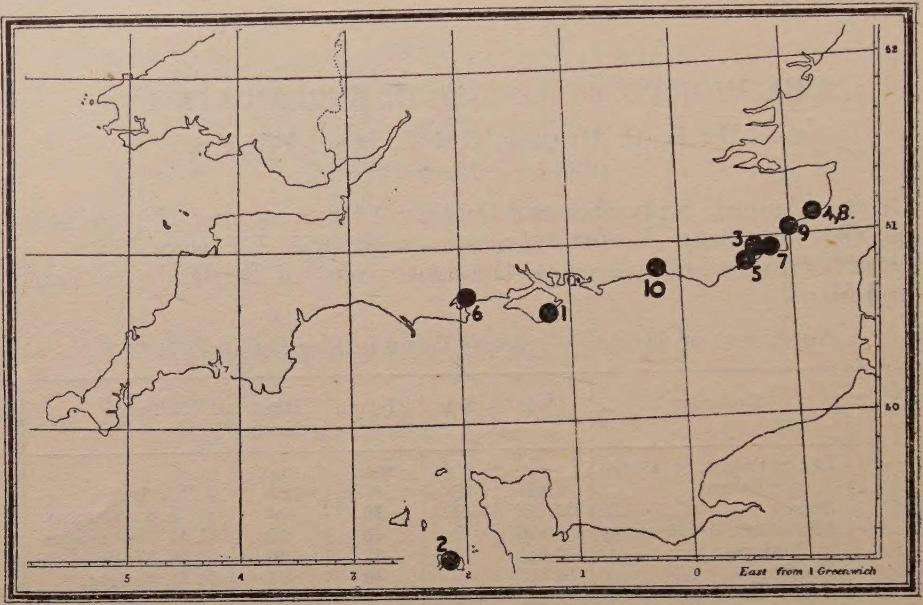
During August, September and October, 1946, a number of individuals of the Migratory Locust (*Locusta migratoria* L.) were taken or observed in various places on the south coast of England (see Table and Map).

Specimens of *Locusta migratoria* taken in England in 1946.

	Locality	Date	Sex	Elytron mm.	Hind femur mm.	Collector
1	Isle of Wight, St. Boniface Down ...	6.viii.	♀	47·7	24	J. W. Saunt.
2	Jersey	31.viii.	♀	46	24	W. J. Le Quesne.
3	Icklesham, nr. Hastings	viii.	♀	46	23	G. G. Woodrivers
4	Folkestone	6.ix.	♀	47	26	J. W. Walton.
5	Hastings	16.ix.	♀	46	24	F. H. Knight.
6	Poole	ix.	♀	—	—	?
7	Rye	x.	♀	47·2	24	A. R. Jacobs.
8	Folkestone	x.	♀	46	24	J. W. Walton.
9	Dymchurch	viii.	♀	44	24	K. A. Crowson.
10	Southwick	28.x.	♀	—	—	G. W. Russell.

Although not more than eight specimens were available for study, it at once became apparent that they were all of the swarming phase (ph. *gregaria*), and also of a different race from the subsp. *migratoria* L. which frequently reaches this country from its well-known outbreak areas on the Black Sea (Waloff, 1940). Fortunately, owing to the courtesy of Professor Trouvelot and of Monsieur Remaudière, I had before me a series of specimens of *L. migratoria* ph. *gregaria* from the swarms which appeared in 1945 in the Landes region of S.W. France (departments of Gironde and of Landes). According to French colleagues who are making an intensive study of the outbreak (Couturier, Remaudière et Arnoux, 1946) the Landes race is well characterised biometrically and can be distinguished at once from the subsp. *migratoria* by the shorter elytra. In the eight British female specimens examined, the length of elytron varied from 44 to 47·7 mm.; the average length in females of the Landes race is 45·7 mm., while in the swarming phase of subsp. *migratoria* the length is in the range 49–59 mm. (Waloff, 1940). Apart from the elytral length, British specimens are undoubtedly referable to the Landes race by other characters, so that the source of this immigration is beyond doubt.

The outbreak in Landes, where the locust has always been known to occur only in the solitary phase, presents some extremely interesting aspects. Data collected by French authors (Vayssière et Feytaud, 1945; Carayon, 1945; Couturier, Remaudière et Arnoux, 1946) suggest that abnormal increase in the population of locusts in that area must have



Map of Southern England showing the places where locusts have been taken or observed in 1946.

Figures refer to numbers in the table on p. 35

been favoured by a series of four very dry years (1940–1944). The drought encouraged extensive fires, which were followed by the growth of a grass, *Molinia caerulea,* an excellent food plant for locusts, during a season when the ordinary graminaceous vegetation becomes withered. Burnt-up patches also offered excellent conditions for oviposition by female locusts. The region being very thinly populated, no attention was paid to locusts, until 1944, when a hopper band was discovered at Gargails (Gironde). The general situation at the time was such that no measures of any kind could have been taken and in 1945 numerous hopper bands and adult swarms made their appearance. At least one swarm flew over Bordeaux, causing considerable public excitement.

In 1946, as M. Remaudière kindly informed me in a letter, the invasion developed on a very serious scale, and during early August large swarms left the areas of their origin and flew mainly north, while some spread westwards. Isolated individuals were captured as far north as the Seine et Oise department, and even in the department of La Manche.

British records, shown in the Table and the Map, prove that the dispersion of isolated individuals was even wider than reported by the French authors. Some of these individuals must have flown nearly 600 miles from their place of birth, probably by stages. It is worthy of notice that a specimen was taken in the Isle of Wight on the 6th August, when the emigration from the outbreak areas had only just commenced ; it must have travelled fast. The specimens taken in October may have arrived earlier.

It would appear that, at least in one case, a group, or a swarmlet, reached this country, since Mr. J. W. Walton reported some nine specimens seen at the same time at Folkestone.

All specimens examined by me were females. None were in a state suitable for dissection, but a female taken by Mr. J. W. Russell at Southwick was reported by him to have laid eggs in captivity. A female taken at Icklesham had the ovipositor smeared with the secretion which is emitted during oviposition. Therefore, at least some locusts arrived ready to lay eggs and it is not impossible that some actually laid them. The chances of the eggs surviving the English winter, which is too mild and humid for their successful hibernation, are extremely small. Thus, although the outbreak in France had some considerable, if local, economic consequences, there can be no danger of the locust becoming established in this country.

It is possible that a similar immigration will recur in 1947, and observers on the south coast of England may render valuable service to the study of insect migration by prompt and detailed reporting of immigrant locusts.

I am very grateful to all those who sent me their records, or specimens, and to M. Remaudière for his generous co-operation and for allowing me to use his unpublished data.

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ON THE FALSE-CHELATE LEG OF AN AQUATIC BEETLE LARVA

By J. Balfour-Browne, M.A., F.R.E.S.
(British Museum (Natural History).)

Amongst material from Connecticut submitted for identification by Miss G. E. Pickford of the Osborne Zoological Laboratory, Yale University, was a single preserved larva of a genus of Colymbetine Dytiscidae which was found to possess an apparently raptorial development of the two anterior pairs of legs that was quite unparalleled amongst the larvae of the Dytiscidae known to me. An urgent request to Miss Pickford for living material was very kindly and promptly responded to and seven living larvae were successfully brought over by her by air; it was thus possible, by breeding through, to identify the larva as that of *Matus bicarinatus* (Say). It was also possible to make some experimental observations on the behaviour of the larva with different types of prey.

At first sight the tibia and tarsus of the two anterior pairs of legs appear to be developed as a chela or raptorial leg—a matter for some surprise since the larva possesses a very well-developed pair of typically Dytiscid raptorial mandibles. On close examination the chelate structure is seen to be formed by the development on the ventro-distal end of the tibia of a long, anteriorly convex, posteriorly concave, marginally serrated process against the antero-ventral face of which the tarsus lies. The tarsus has the antero-dorsal edge marginally serrated, the serrations flat and laminate. The distal end of the tarsus bears two claws, a longer anterior one and a shorter posterior one. It must be emphasised that when opposed the postero-ventral face of the tarsus overlaps the anterior portion of the dorsal face of the tibial process, the marginal serrations of each piece not, at any point, meeting edge to edge.

In general the raptorial legs of the Arthropoda show a striking similarity of structure. This similarity cannot be due to phylogeny and it may, therefore, be a phenomenon of convergence. Rabaud (1923) in discussing this question has pointed out that an investigation of the relation between a given behaviour and a given food-habit shows that these factors do not, of necessity, determine the form of the leg. For example, in the Hemiptera both the Phymatidae and the Reduviidae feed on living prey which they seize between the femur and tibia of the anterior pair of legs. Yet in representatives of these two families the structure developed is radically different, *Carcinochelis* of the Phymatidae having developed a long process of the femur against which the tibia articulates edge to edge, whereas in *Reduvius* the tibia is hinged distally on the femur and articulates in normal manner against the under-surface of the femur, both being more or less dentate on the ventral surface. Rabaud concludes his discussion by emphasising that in the adephagous Coleoptera the raptorial function is entirely a property of the mandibles in the

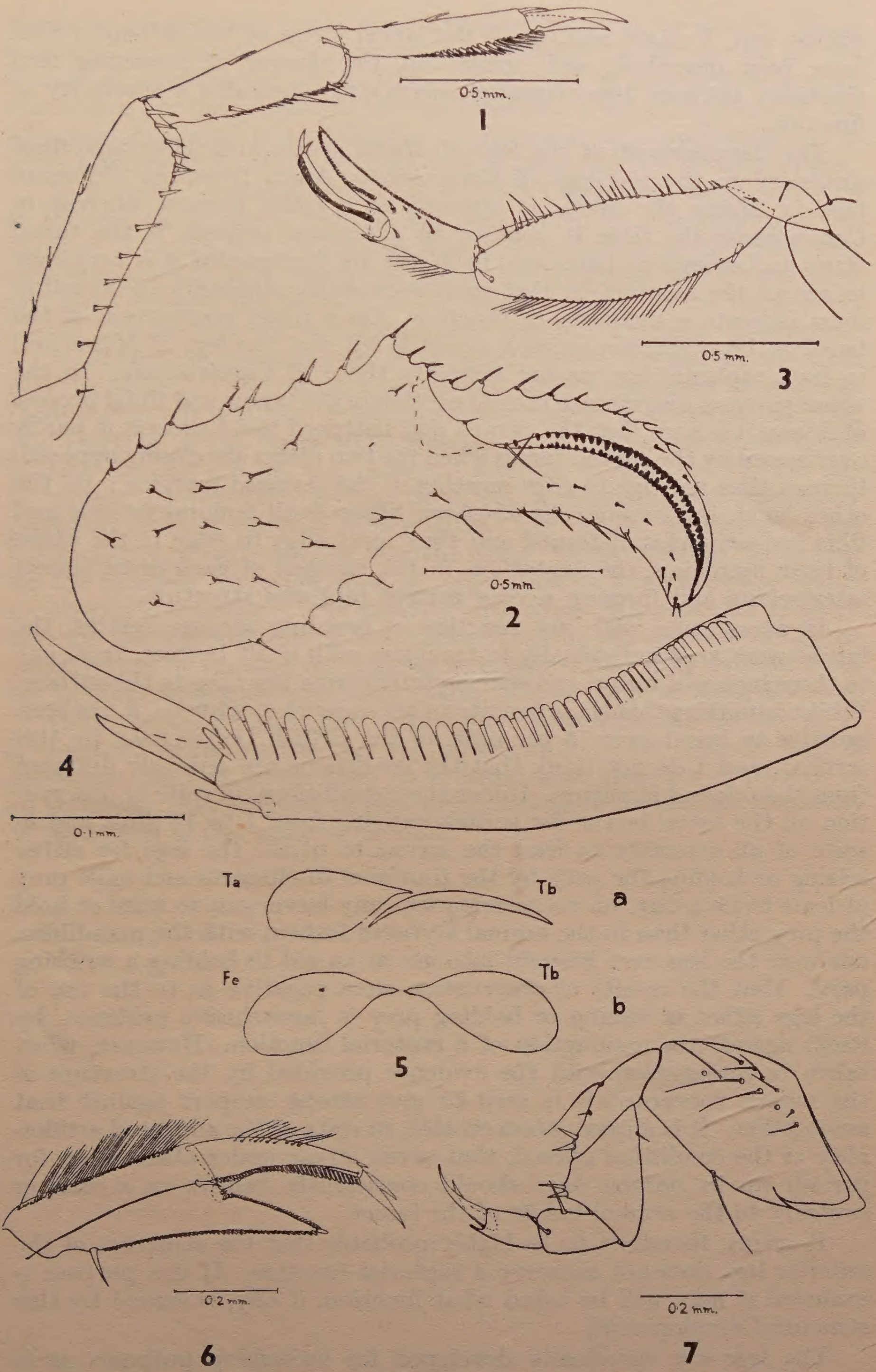

Fig. 1.—*Ilybius ater* (Deg.). L.III. Anterior leg, anterior face.
Fig. 2.—*Carcinochelis binghami* Sharp. Left anterior leg—apex of femur and tibia.
Fig. 3.—*Matus bicarinatus* (Say). L.III. Anterior leg, oblique externo-posterior aspect.
Fig. 4.—*Matus bicarinatus* (Say). L.III. Mesotarsus, anterior face (swim hairs omitted).
Fig. 5.—Diagrammatic transverse section of (*a*) tibial process and tarsus of *Matus bicarinatus* (Say); (*b*) *Carcinochelis binghami* Sharp, tibia and femur.
Fig. 6.—*Matus bicarinatus* (Say). L.III. Mesotibia and tarsus, anterior face.
Fig. 7.—*Noterus capricornis* Hbst. Mesothoracic leg (anterior side).

adults, and, I might add, in all the larval forms of the sub-order that have been described, and points out the danger of assuming that similarity between two structures necessarily indicates a similarity of function.

The development of the legs of *Matus* shows a striking superficial similarity to the fore-legs of *Carcinochelis*. Apart from the difference that in *Matus* the tarsus is opposed to a tibial process whereas in *Carcinochelis* the tibia is opposed to a femoral process, if the tarsal claws and swimming-hairs seen in *Matus* are disregarded it is very easy to accept the assumption that such remarkable similarity of structure must indicate a similarity of function. On a closer comparison of the two legs, however, considerable doubt is felt that the legs of *Matus* are, in fact, raptorial legs as are certainly those of *Carcinochelis*. In the accompanying diagrammatic cross-section of the tarsus and tibial process of *Matus* it is seen that the curved and flattened tibial process is partly overlapped by the curved tarsus when the two pieces are closely opposed: there is thus no edge to edge meeting of the serrated margins ; on the other hand, in *Carcinochelis binghami* Sharp both femoral process and tibia are somewhat flattened and they meet edge to edge in the plane of their flattening, the dentations in the margins of each piece almost interlocking and forming a very perfect raptorial structure.

In accordance with my practice in breeding aquatic beetles, the larvae were kept individually in tumblers with a silt bottom, from one to three inches of water, and with aquatic plants reaching to the surface. Whilst admitting that these conditions are somewhat artificial, it has been possible to breed over 75 per cent. of the British DYTISCIDAE by this method, and I do not think that the conditions are seriously different from those found in nature. Under these conditions, in spite of observation on the seven larvae for periods ranging from 7 to 16 days and in spite of all attempts to lead the larvae to utilise the legs for either seizing or holding the prey by the provision of elongate and agile prey at least twice a day, on no occasion was any larva seen to seize or hold the prey other than in the normal Dytiscid fashion with the mandibles, nor were the legs ever brought into use as an aid to holding a writhing prey. That the results of observation were negative as to the use of the legs either in seizing or holding prey is inconclusive evidence, by itself, against the assumption of a raptorial function. However, when taken in conjunction with the evidence provided by the structure of the organs concerned it is seen to give strong support against that assumption. It is almost inconceivable, in spite of the admitted artificiality of the conditions offered, that seven larvae under observation for periods up to sixteen days should consistently behave in a manner contrary to the normal habits of the insect.

It seems, therefore, to be highly probable that the structure of the anterior legs does not subserve a raptorial function. If this purpose is excluded it may well be asked what function, if any, is served by this structural development.

The legs are specifically developed for swimming purposes as is proved by the fringe of hairs developed on the postero-dorsal edge, a character present only in the more advanced forms in the family. There is, therefore, no additional swimming advantage to be served by the structural modification of the tibia and it must be accepted as certain that this is not the purpose of the modification. I would suggest that the structure described is a particular development of a swimming-leg to serve a fossorial function, without loss of efficiency for either purpose.

In a normal fossorial leg in the aquatic Coleoptera, such as is seen in *Noterus*, the fossorial function has been served by a shortening of the leg and, in particular, by a broadening and deepening of the trochanter and femur which have much lengthened the suture on which they meet and have reduced the freedom of the femur to pivot on the trochanter. It will be seen that the tarsal claws are retained virtually unreduced.

In *Matus* the development of an acute, serrate process on the tibia and the ability of the tarsus to fit closely against the tibial process has produced an efficient tool which direct observation confirms as effective. The reaction of the larva when startled is an immediate dive for the bottom silt and a rapid and powerful attempt to bury itself in the silt by violent digging with the four front legs, a reaction which invariably produced a thick cloud of debris behind the insect. In larvae of the Colymbetinae with normal legs the usual "fright-reaction" is to bolt for the thickest cover provided by vegetation or loose debris in which no digging is necessary. The rapidity with which *Matus* is able to move through the water attests to the efficiency of the legs for swimming; the effectiveness of the legs for digging purposes is also fully evident from the rapidity with which the larva is able to bury itself on being alarmed.

Only the second and third instars have been available for study. It is therefore unknown whether the modification of the anterior legs is present in the first instar also. It is hoped that imagines at present in an aquarium may oviposit in the spring and allow further investigation of the habits of the larva to be made.

SCENT PERCEPTION IN SOME AFRICAN MYRMECOPHILOUS LYCAENIDAE (LEPIDOPTERA : RHOPALOCERA)

By C. Cripps.

Some years ago, whilst searching for larvae, I noticed a female of *Euchrysops crawshayi* Butler hovering about over some grass as though looking for a plant upon which to deposit eggs. The time was about 12.30, the weather sunny.

I looked about for the particular food-plant, *Cynoglossum coeruleum*, and after a great deal of search found a miserable half-dead plant, about two inches high, growing between grass stems and rubbish. Standing some way off I watched the butterfly find this one solitary plant. Having found it she immediately laid one egg on its single green leaf, and flew off as I approached. I then examined the egg and covered the plant with twigs, grass, etc., so that nothing of it could be seen from above. I now sat nearby in the expectation that the butterfly would return to lay again. She soon appeared, coming from the west, zig-zagging as she neared the plant, which was eventually found and upon which another egg was deposited. In each case the butterfly flew up against the wind which was blowing quite strongly at the time.

I concluded that it must have been by scent of the plant, and not by sight, that the butterfly was able to find it. It is remarkable that the insect was able to pick out this single plant from among the dozens of other types of plants, each with its particular scent.

Since making the above observation I have often watched many other females do exactly the same thing. They always appeared from down wind, zig-zagging up to the food-plant. If they got beyond it and lost the scent they immediately flew round down wind and started all over again. Similarly, males of species of *Neochrysops* Bethune-Baker, when disturbed from resting on a grass stem, would always approach the same stem from down wind, zig-zagging up against the wind before coming to rest upon the original stem.

The larvae of species of *Neochrysops* (*N. victoriae*, *patricia* and others) possess a certain scent which is evidently pleasing to certain ants ; ants also possess this scent. I have often watched ants with larvae of *Neochrysops* kept under an inverted glass finger-bowl on my table. Upon several occasions I have allowed an ant to escape, then picked it up between finger and thumb and returned it to the bowl. Generally two ants would approach and inspect the newly arrived one, possibly to smell it. They would then commence to brush and clean it up very thoroughly indeed, until every part of its body had been gone over. This operation either removed all the scent from my hands or covered the ant with a scent common to all ants in this colony. *Neochrysops* larvae in this colony were treated by me in the same way, and upon their return to the bowl would be thoroughly cleansed by the ants, being afterwards transported to a safer spot in the earth, in a tunnel, away from any light and where I could not see them.

In May, 1942, I collected over 60 larvae of a *Neochrysops.* Not knowing where to put them all, I kept about 25 for inside work and put 35 or 40 into an ants' nest on the lawn. Those taken inside were part of the original colony of ants and larvae, whilst the ants outside were not and only belonged to the same species.

Most of these *Neochrysops* larvae were in the fourth instar, and some more advanced. I took care not to handle them and placed each near an ant hole. The larva was at once seized by an ant and carried below, and so all were transported. I then covered the area of the nest with fine gauze in order to trap any butterflies which might emerge.

When the larvae indoors started to pupate I thought I would bring in the pupae from outside. Upon digging I was surprised at finding no trace of any larva nor pupa. This I attributed to scent. The scent of the larvae was probably strange to these ants in which case they most likely destroyed the larvae. On the other hand, the larvae indoors, with the orginal ants, pupated and the adults emerged in due course.

After the rains had started this year (1942) I stood one day in the garden watching many ants busy removing earth from below ground. I stood about two feet away with the wind blowing from ants to me. Presently I leaned over the ants and extended an arm with the hand on the other side of the colony ; the wind was now blowing from my hand to the ants. No sooner had I done this than the ants appeared very disturbed and started to rush about in all directions.

At another time I was watching ants travelling up the trunk of a tree, all following a certain path, with wide gaps between each individual. I lightly rubbed a finger once across the pathway. When the next ant arrived at this spot it suddenly stopped, then went from side to side as though seeking a crossing ; other ants arrived and did the same thing, until one found a spot to the right of the path where my finger had not touched the tree. It was not long before all the ants were travelling up and down along the new path.

On other occasions, when digging for larvae of *Neochrysops,* I handled a few before returning them to the ants or placing them near the entrance to the nest. The larva was always inspected or smelled and then brushed, as previously recorded, after which it would be carried below.

Many ICHNEUMONIDAE are parasitic upon the Lycaenid larvae and, as adults, emerge within the ants' nest and finally crawl out through the tunnels in the same manner as the butterfly. These are not molested by the ants. As the Ichneumon has lived through the larval and pupal stage of the butterfly I conclude it possesses the proper scent which protects it from the ants.

THE EARLY STAGES OF SOME AFRICAN LYCAENIDAE (LEPIDOPTERA : RHOPALOCERA)

By T. H. E. Jackson, F.R.E.S.

Capys catharus Riley.

Capys catharus Riley, 1932, *Ann. Mag. nat. Hist.* (10) **10** : 144, pl. viii, figs. 6 and 7, ♂ ; ♂, Region de M'Pala, Tanganyika Prov., Belgian Congo.

Food-plant.—A species of *Protea* (Proteaceae). The larva burrows into the young unopened buds. It may be found occasionally in flowers just after they open.

Egg.—More rounded than the usual Lycaenid type, with circular flattened base, patterned with a rough reticulation. White, with a diameter of 0·75 mm. It is laid on the immature buds, usually near the stalk.

Larva.—The newly-hatched larva immediately burrows into the flower-bud. Mature larva reddish-brown with black spiracles and a black patch and spots on the collar ; segment rings with thick black transverse bars. Shape somewhat flattened, tapering gradually to the anal extremity, with well-defined segmentation and scalloped lateral edges. Anal segments flattened and shield-shaped. On either side of the shield are a pair of tubercles somewhat resembling the spiracles but brown instead of black, and more widely oval. Under stimulation from an ant or hair-brush, these spiracles appear to open, disclosing a whitish interior ; upon one occasion, under extreme provocation, an opaque white substance was exuded. Neither gland nor tubercles appear to be present. Head large, protected by a heavy sclerotised collar. Until the last instar the skin is smooth, polished and semi-transparent. When full-grown it is roughened and coated with short spiny hair. Length 20 mm.

Pupa.—In captivity, placed on bark and well hidden, being dark blackish brown. It is regularly formed with a slight waist, the abdominal segments being wide and flattened, but rising above the level of the thoracic segments. The female pupa measures 13 mm. × 6 mm., the male being slightly smaller.

Habitat.—Kenya : Trans Nzoia.

Epitola crippsi Stoneham.

Epitola crippsi Stoneham, 1933, *Bull. Stoneham Mus.* **17** : pl. ii ; ♀, Kenya Colony.

Egg.—Not known.

Larva.—On the bark of trees, usually in fairly open country. Although *Crematogaster* ants are always present, they do not appear to attend the larvae. The food is thought to be lichens.

Exactly resembles the larva of the common Lymantriid moth, *Naroma signifera* Walker, only lacking the dorsal tufts of this insect. Found among the ant-runs on the tree trunks in company with the

Lymantriid. Anteriorly broader than the *Naroma*. Collar whitish green, followed by a black band, a broad whitish band and another black one; segments 6 to 9 white, 10 black, anal segments white; an entire lateral fringe of tufts of hair. Length 25 mm.

Pupa.—A wonderful example of procrypsis, resembling exactly the common species of lichen among which it is placed. This lichen, occurring on the trunks of most trees, is foliaceous and pale green, covering all the irregularities of the bark, and having rounded, scalloped, exterior margins; occasionally with outgrowths of black, spiny spores.

Pupa with dorsal region pale green with a central thoracic and abdominal row of a few black spines resembling the lichen spores. Lateral margins scalloped. Shape similar to that of *Hewitsonia kirbyi intermedia* J. & T. Thorax domed; collar shovel-shaped but bluntly bilobed; abdominal segments broad with a dorsal median ridge and scalloped edges. The head-case is carried ventrally. The wing-cases curve up to meet the green dorsal surface at its scalloped edge; they are coloured brown and black like a piece of the curled-up undersurface of the lichen.

Just before emergence the pale green colour turns grey, but the two lobes of the collar remain green, forming by contrast a striking resemblance to a pair of staring eyes. Length 20 mm., width 8 mm.

Habitat.—EASTERN UGANDA: Busia.

Only females were bred. These differ from the nominotypical *crippsi*, described from Soy, Kenya, in having an additional white spot in area 2 of the fore-wing.

Deudorix odana Druce.

Deudoria odana H. H. Druce, 1887, _Ent. mon. Mag._ 23 : 204; ♂, West Africa, Cameroon Mts.

Food-plant.—The seed pods of an undetermined species of tree belonging to the LEGUMINOSAE.

Egg.—Deposited on the leaves or stems of terminal shoots. Large, nearly 1 mm. in diameter, evenly domed, with a minute apical depression, and finely sculptured. Colour white or very pale green.

Larva.—When half-grown it is hairy and reddish-brown; segments 5 to 8 with a large red patch, 1 and 2 wholly red and greatly swollen; segment 2 with a small highly polished sclerotised patch; head large, black and polished; anal segments flattened and shield-shaped; no sign of tubercles or gland.

Mature larva dull greyish-brown with five rows of prominent black spots, not reaching the flattened anal segments. Collar and segment 2 bright shiny red; segments 3 and 4 black; small hairy tufts arise in rows between the black spots. Body broad, and segmental divisions very corrugated. Length 18 mm., width 5 mm.

Pupa.—Light brown, darker along sides of thorax, with dorsal rows of small black spots. Thorax slightly domed and rather longer than usual for the genus, otherwise a typical *Deudorix* pupa. It lies flat, within the seed pod. Length 11–12 mm.

Habitat.—UGANDA: Katera—Malabigambo Forest.

Deudorix camerona Ploetz.

Sithon cameroni Plötz, 1880, *Stettin. ent. Ztg.* 41 : 201 ; ♂, Cameroons.

Food-plant.—Larva found among ants under bark, looking for a place to pupate.

Egg.—Not known.

Larva.—Onisciform and very broad, with segmental divisions sharply defined, and skin much roughened. Collar rounded and projecting ; anal segments flattened, carrying a gland and two minute tubercles. The tubercles are tiny white globular organs, with apparently no terminal inflorescence ; they are extruded in the presence of ants, either together or separately. Colour of larva dark sepia. Length 15 mm., width 6 mm.

Pupa.—Brown, much contracted at extremities, otherwise of regular shape without ornamentation.

Habitat.—UGANDA : Katera—Malabigambo Forest.

Stugeta olalae Stoneham.

Stugeta olalae Stoneham, 1933, *Bull. Stoneham Mus.* 17 : ♀, Kenya Colony. Jackson, 1937 *Trans. R. ent. Soc. Lond.* 86 : 213 (err. det.=*Aphniolaus pallene* Wallgr.).

Food-plant.—*Ximenia americana* Linn. (OLACEAE), the young leaves.

Egg.—Not known.

Larva.—Green ; a dorsal fine dark brown line not reaching anal segments ; a lateral row of minute black dots just above edge of carapace. A dorsal ridge, knife-edged, rising evenly to a point just above collar where it is cut off abruptly, forming a roughly flattened area protecting the head. Head never visible, even when feeding. Legs not visible, being protected by a heavy close-fitting carapace on all sides. The dorsal line divides on the flattened frontal part to form a circular mark, uniting again along the collar. Anal segments flattened, and posteriorly sharply bifurcate.

In its later stages this larva bears a superficial resemblance to *Aphniolaus pallene* Wallengren, since both change to greyish-white and black before pupating. Both feed on the same plant.

Pupa.—Dark brown to black, resembling *Ximenia* bark. It is attached by the anal appendages flat on the bark. The pupa tapers posteriorly to a short broad stalk ; it bears two dorsal blunt hook-like processes. Length 13 mm., width 7 mm.

Habitat.—KENYA : Kitosh, Kavirondo.

The author is of opinion that *S. olalae* is a form of *S. marmorea* Butler.

Spindasis sp. (? *natalensis* Westwood).

Aphnaeus natalensis Westwood [1851], *in* Westwood, Doubleday and Hewitson, *Gen. Diurn. Lep*, 2 : pl. 75, fig. 4 ; [Port Natal].

Food-plant.—*Ximenia americana* Linn. (OLACEAE). The larva feeds on the leaves and is ant-attended.

Egg.—Not known.

Larva.—Dorsally light greenish-brown, collar and anal segments dark brown, laterals greenish-white, the whole surface covered with minute white papillae. Along the edges of the laterals are rows of long white spines arranged in pairs ; two rows of shorter single spines are ranged along the dorsum. Head large, brown, protected by a collar. Anal segments rounded, with suranal plate. Just anterior to the suranal plate are two small tubercular processes holding papillae. When stimulated the papillae are exserted and oscillate rapidly, the general direction being inwards. These papillae are white with an extrusable terminal rosette of very fine spiny hairs ; although the movement is very rapid it is possible to see these hairs shot out at each outward stroke of the papillae. A large oval gland is situated centrally anterior to the tubercles. Length 18 mm.

Pupa.—Polished black with narrow head and prominent shoulders. The posterior segments are contracted and tucked underneath where they are attached to the bark. Length 10–11 mm.

Habitat.—Kenya : Kavirondo.

Axiocerses harpax Fabricius.

Papilio P. R. harpax **Fabricius, 1775, *Syst. Ent.* : 829 ; "America."**

Food-plant.—The larva lives among ants under the bark of *Acacia stenocarpa* and probably of other trees. It is gregarious, sometimes two or three or as many as ten being found together. The ants, a small black species of *Crematogaster*, are constantly in attendance at the larval gland. The larvae are always in the dark, following the ant-runs even below ground.

Larva.—Dull greenish anteriorly, fading to brownish-green at the anal extremity. Very hairy, the hair arising from warts arranged in double rows around each segment. Head large, shiny black ; collar with a black sclerotised patch, regular in shape, though slightly broader anteriorly. Anal segments unusual : last segment flattened and semicircular, guarded above by a black sclerotised plate ; there follows an elevated ridge beyond which is a depression ; exactly above the depression lies the orifice of the gland between two black spots. The orifice appears as an opaque patch in a polished oval plate of light-coloured chitin, and on either side are tubes containing the tubercles, plainly visible organs of a pale colour surrounded by black rings. The tubercles carry a long spiny rosette at each extremity ; they are, apparently, only exserted when an ant is actually feeding at the gland. They then appear as dirty white organs, and are shot rapidly in and out, three or four times, at an angle inwards of the vertical, the long terminal spines or hairs, on each occasion, coming in contact with the ant and interlocking over its back from either side. The ant responds by raising its head, but does not necessarily leave the gland. Under a lens it can be seen that the stalks of the tubercles are finely fluted. Length of larva 20 mm.

Pupa.—Brownish-black. Thorax domed, and shoulders rather prominent. Formed under bark and attached by the anal extremity, which is pointed and curled under the abdomen. Length 12 mm.

Habitat.—Kenya : Mt. Elgon.

Biology.—The larval food appears to be some concentrate, such as honeydew, either dropped by the ants from their mouth-parts or excreted by them in passing along the tunnels and runs, being carefully collected by the Lycaenid larvae.

The mouth-parts of all larvae of this type (*e.g.*, *Chloroselas*, *Spindasis*, etc.) are minute and probably incapable of biting large, solid substances. Observation of larvae in the ant-runs always reveals the same habit. The larva makes a slow, careful investigation with the mouth of every part of the surface of the runs, accompanied by movements of the mouth-parts as of feeding. The food must be very concentrated since all larvae of this type can live for long periods without food.

The majority of ant-attended larvae are not carnivorous unless starved and confined together in a restricted space, when some may eat the others.

Anthene sobrina Talbot.

Lycaenesthes sobrina Talbot, 1935, *Ent. mon. Mag.* **71** : 208, pl. iv., fig. 12, 13 ♀ ♀, West Kenya Colony.

Food-plant.—*Acacia* sp.

Egg.—Not known.

Larva.—Much narrower than and obviously distinct from its allies, *pitmani* Stempffer and *otacilia kikuyu* Bethune-Baker. Dorsum almost smooth, not corrugated as in the species cited. Body green or dark red with a dorsal series of diagonal sagittate marks in red, carmine and white. A dorsal fine dark line, broader along the anterior segments, ending at segment 9. Spiracles sharply lined in white with a dark red border. There is much minute black papillation.

The larva is constantly ant-attended, and both tubercles and gland are present. The gland is placed centrally on segment 10, between and in front of the two tubercles ; orifice narrowly oval. The tubercles are carried on raised shoulders on either side of segment 11 ; they are short, thick, translucent white organs with a terminal spiny rosette. Length 13 mm., breadth 2 mm.

Pupa.—Greyish or green with a dorsal fine black line, lateral black spots and a short black dash on the head-case. At the junction of the thoracic and abdominal segments is a white diamond-shaped mark. General shape similar to that of other *Anthene*, regular, with a very slight waist ; head-case small. Length 7 mm.

Habitat.—KENYA : Katheleba ; Suk.

Anthene lamias Hewitson.

Lycaenesthes lamias Hewitson, 1878, *Ill. Diurn. Lep. Lyc.* : 227, pl. xci, figs. 25, 26 ; West Africa.

Larva.—Green, with a dorsal darker and very indistinct line. Just above the head is a small sclerotised reddish-brown oval spot. Shape regular, the dorsum evenly rounded. Tubercles and gland absent, although the larva feeds on terminal shoots usually infested with ants. Length 10 mm.

Pupa.—Green, with two latero-dorsal rows of minute black spots. Shape regular. Length 7–8 mm.

Habitat.—UGANDA : Malabigambo Forest, Katera.

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CRIPPS, C., and JACKSON, T. H. E., 1940, The life-history of *Lachnocnema bibulus* (Fab.) in Kenya, with a note on the larval gland by Dr. H. Eltringham, F.R.S. *Trans. R. ent. Soc. Lond.*, **90** : 449–453, fig 1. pl. 1.

ON THE PROBABLE CENTRE OF DISPERSION OF THE GENUS *NEWSTEADIA* GREEN (HOMOPTERA, COCCOIDEA)

By Raymond Mamet.
(*Rose Hill, Mauritius.*)

The whole question of the centre of dispersion of the genus *Newsteadia* Green has now to be revised with the discovery of another species of this genus (*N. montana* Mamet) in Mauritius. In fact, Mauritius is the only locality in the world where two species of *Newsteadia* have so far been recorded.

Before arriving at a conclusion about the centre of dispersion of the genus, it would be interesting to review the status of all the species which have either been described in, or assigned to, *Newsteadia*. At the present juncture, only five species have definitely been assigned to this genus—viz., *floccosa* de Geer, *tristani* Silvestri, *americana* Morrison, *mauritiana* Mamet and *montana* Mamet. Another species which has been described as belonging to *Newsteadia* is *myersi* Green. As stated elsewhere (1943, *Bull. ent. Res.* **34** : 120), *myersi* can doubtfully be kept in the genus and appears to be more related to *Ortheziola* Sulc.

N. floccosa de Geer (1778), the type of the genus, was primarily described from the European Continent and subsequently recorded in Australia. Morrison (1925, *J. agric. Res.* **30** : 146 and 151) regards the presence of this species in Australia as being presumably due to some accidental introduction. I am of opinion that the contrary would be more plausible. This assertion is based on the known fact that it has always been a custom to introduce plants, herbs, etc., from tropical or subtropical countries to metropolitan (generally European) countries for the purpose of establishing tropical gardens there. *N. floccosa* may therefore have escaped from one of these tropical gardens and then taken a strong foothold in the country in which it had first been accidentally introduced and then distributed to other countries of Europe by the usual channels of exports. This is furthermore supported by the fact that *N. floccosa* has been met with on various hosts which include plants belonging to the CYPERACEAE, LABIATAE, GRAMINEAE, CISTACEAE, JUNCACEAE and on the Musci, thus increasing the chances of introduction from one country to another. The other species, on the other hand, have been met with on rotting timber or on disintegrated vegetation, thus rendering the chances of introduction to other countries fairly negligible. It must also be emphasised that the description of a Coccoid from a certain country does not at all mean that this Coccoid has its endemic habitat in that particular country. In other words, *N. floccosa* may have been first described from Europe, but this does not mean that Europe is the country of origin of this species. In conclusion, *N. floccosa* should be regarded as an Australian (Tropical or Subtropical) species rather than as a European (Palaeartic or Holartic) species.

N. tristani Silvestri (1924) was first described from Costa Rica

(Central America) on disintegrated vegetation, as *Ortheziola tristani*. Morrison (*loc. cit.*, p. 151) relegates this species as an immature stage of some species of *Newsteadia*, on account of the absence of the characteristic ovisac band which is always present in mature females of the genus. This record of a species of *Newsteadia*, either mature or immature, must stand for the purpose of discussing the problem of the probable centre of dispersion of the genus.

N. americana Morrison (1925) was collected on rotting logs and among trash on the shore of the Potomac River, opposite Plummer's Island, Maryland, United States of America, and from Grimsby, Lake Ontario, Canada. It is most probable that this species comes from another country, probably an African one, and has been washed ashore in North America by the strong and warm Equatorial sea currents which converge near the North American coast to form the well-known Gulf Stream. Coccoids of this genus are generally well protected against the action of water by the presence of compact, waxy secretions which cover both their ventral and dorsal surfaces. Moreover, *N. americana* feeds on rotting logs, probably on hyphae of fungi or on musci. Thus, both characters—*i.e.*, secretions and feeding habits—together tend to permit the species to withstand a long sea journey.

The other known species of *Newsteadia*, *N. mauritiana* Mamet (1943) and *N. montana* Mamet (1947), occur in Mauritius. They have been collected in the midst of indigenous forests which still exist on some of the mountains of the island (Cocotte Mt., Corps de Garde Mt., Le Pouce Mt., Berthelot Peak) and were feeding on saprophytic musci growing on rotting pieces of fallen indigenous wood.

The genus *Newsteadia* is therefore represented in the World by five species, of which one feeds on phanerogams whilst the others have been collected on rotting vegetation. Of these five species, two (*floccosa* and *trustani*) are subtropical, one (*americana*) probably and two (*mauritiana* and *montana*) definitely tropical.

It follows therefore that the genus *Newsteadia* has a tropical origin and facts, up to the present, would seem to point out that the probable centre of dispersion of the genus is somewhere in the Tropical Zone and presumably in one of the countries washed by the Indian Ocean. It should, however, be clearly understood that this statement is liable to revision since members of this genus have apparently not been especially searched for by workers in the group.

P.S.—Since writing the above, I have been informed (*in. litt.*) by Dr. W. J. Hall of the Imperial Institute of Entomology that he has received examples of a new species of *Newsteadia* from the Gold Coast (Africa). This new species has been collected on living cocoa plants, *Theobroma cacao*, and on *Triplochiton scleroxylon*, both plants belonging to the STERCULIACEAE.

The discovery of another species of *Newsteadia* in Tropical Africa has therefore helped to strengthen my views that the genus is most probably of tropical origin, but has in no way persuaded me that its probable centre of dispersion lies outside the tropical countries bordered by the Indian Ocean.

BOOK NOTICE.

Insect Microbiology. By E. A. Steinhaus. 8vo. New York (Comstock Publishing Co.) and London (Constable & Co.) 1946. Pp. x+763, text illust. Price £2 5s.

In this work the author has brought together in one book all the information on insect microbiology hitherto not available in any readily accessible form. It attempts to "treat the various associations and relationships existing between all types of microbes and insects (including ticks and mites) from a biological standpoint."

There are chapters dealing with the following subjects: Extracellular Bacteria and Insects, Specific Bacteria associated with Insects, Intracellular Bacteriumlike and Rikettsialike Symbiotes, Rickettsiae, Yeast and Insects, Fungi and Insects, Viruses and Insects, Spirochetes associated with Insects and Ticks, Protozoa and Insects (except Ticks), Protozoa in Termites, Immunity in Insects, and Methods and Procedures.

Great care has been taken to make it a very convenient work of reference, there being a detailed subject index and a bibliography of 89 pages.

THE GILLS OF SOME AQUATIC BEETLE PUPAE (COLEOPTERA, PSEPHENIDAE)

By H. E. Hinton, Ph.D.

(Department of Entomology, British Museum (Natural History).)

The pupae of nearly all Trichoptera and many Diptera are aquatic, but elsewhere among the Holometabola the pupae of only a very few Lepidoptera (Pyralidae), Hymenoptera, and Coleoptera are aquatic. Gills are present in most trichopterous pupae and in those of many Diptera Orthorrhapha, but they have not previously been recognised in the Lepidoptera, Hymenoptera, or Coleoptera.

Although the larvae of many beetles are necessarily aquatic, these larvae nearly always leave the water before pupating; and only the larvae of *Noterus* (Noteridae), *Psephenoides* (Psephenidae), the Donacini (Chrysomelidae), and *Lissorhopterus* (Curculionidae) are known to pupate beneath the surface of water. Of these, all except *Psephenoides*[1] are enclosed in gas-filled cocoons. When the walls of the cocoon are permeable to gases, the air-stores enclosed by them may serve to extract oxygen through the cocoon membrane from the surrounding water.[2] The cocoons of these pupae are attached to the roots of aquatic plants. In at least some—*e.g.*, *Donacia*—the cocoon is not complete on the side attached to the root, and the root is here pierced with minute holes made by the larva. According to some writers, the oxygen supply of the pupa is drawn through these minute holes from the intercellular air-spaces in the root.

The larvae of all Psephenidae except *Psephenoides* (and possibly some *Eubrianax*) leave the water before pupating. The larvae of *Psephenoides*, a genus known only from the Oriental Region, pupate beneath the surface of the water in fast-flowing rivers and torrential streams where their pupae are cemented to the lower surfaces of stones and pebbles (Hora, 1930). From the structure of the larvae, pupae, and adults it is fairly certain that *Psephenoides* is the most specialised genus of the family. The larvae and pupae are better adapted to life in the water than those of any other genus. *Psephenoides* is the only genus of the PSEPHENIDAE which is apneustic in all larval instars (Hinton, 1947) and the only genus which possesses pupal gills ; and in respect of both of these characters it is unique among beetles.

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[1] According to Essig (1926), *Eubrianax edwardsi* (Leconte) pupates in streams beneath the surface of the water, but this requires confirmation.

[2] It is well known that air stores of many insects serve as a kind of gill. As the oxygen is used up, the partial pressure of the oxygen in the air store is chiefly restored by diffusion into the air store of oxygen dissolved in the surrounding water rather than by diffusion of nitrogen out of the air store. This is due to the fact that the invasion coefficient of oxygen between water and air is more than three times as great as that of nitrogen.

[3] The pupa of *P. gahani* has previously been figured and described by Böving (1926, p. 386) as follows: "Spiracles annular, small but distinct, dorsal and located at the basis of and exterior to the thick spines of the second to seventh abdominal segments and on a somewhat corresponding place on the eighth abdominal segment." The illustrations of the pupa (*op. cit.* pl. XC) show annular spiracles on the dorsal antero-lateral angles of the second to seventh abdominal segments and on the postero-lateral angle of the eighth segment. It is necessary to state here that so far as the respiratory system of *Psephenoides* is concerned, Böving's description bears no relation to the facts. The structures which are shown to be gills in this paper are described by Böving (*loc. cit.*) as follows: ". . . . on the second to seventh abdominal segments . . . a very long, stiff and movable spine is found, surrounded by a thick tuft of long soft hairs."

The pupae of two species of *Psephenoides*, *P. gahani* Champion and *P. volatalis* Champion, have been examined. The spiracles of the thorax and the first and eighth abdominal segments are non-functional and are connected to the longitudinal tracheal trunks only by collapsed and more or less solid ecdysial tubes.[3] The spiracular chambers of the second to seventh abdominal spiracles are very greatly lengthened, and into the distal pocket of each chamber open a varying number of very long and slender cuticular gills of curious structure.

The general appearance of the gills of *P. volatalis* is shown in fig. 1.

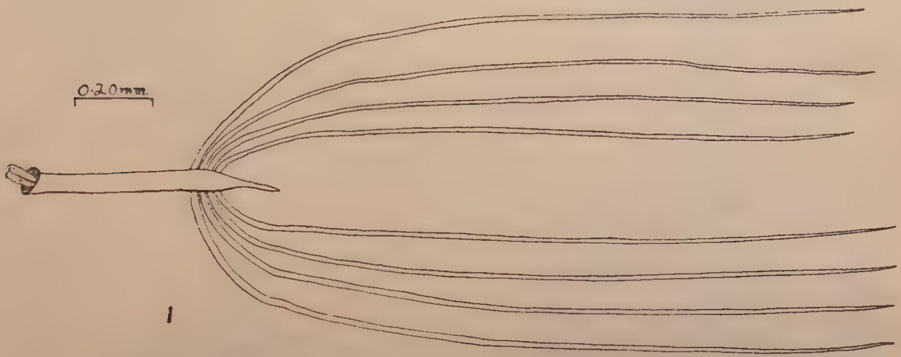


FIG. 1.—Pupa of *Psephenoides volatalis* Champion. Dorsal view of spine and gills of the right side of the third abdominal segment.

The spiracular chamber of each spiracle is rather deeply invaginated into the body (fig. 2) and distally extends into a long, stout, hollow spine projecting dorsally from the body wall. This spine can be regarded as the modified peritreme of the spiracle, and it is a result of a specialisation of the cuticle which constitutes the outer rim of the spiracle of other larvae. The spiracular chamber extends to the apical third of the spine where there are four to ten cuticular gills. The lumen of these gills is continuous with the lumen of the spiracular chamber. The chamber does not continue beyond the point of origin of the gills into the apical third of the spine, which is hollow for a short distance.

The enormously long spiracular chamber is elliptical in cross section (fig. 3) for the first part of its length, but becomes circular as it continues into the spine (fig. 4). Throughout its length it is armed with long cuticular processes so fine that they are difficult to see with a 2 mm. oil immersion objective of 1·4 N.A. These cuticular processes are very dense so that the "felting" of this chamber is finer and denser than that described for most other insects. Their apices overlap and are partly entangled in the centre of the lumen, so that the centre of the chamber

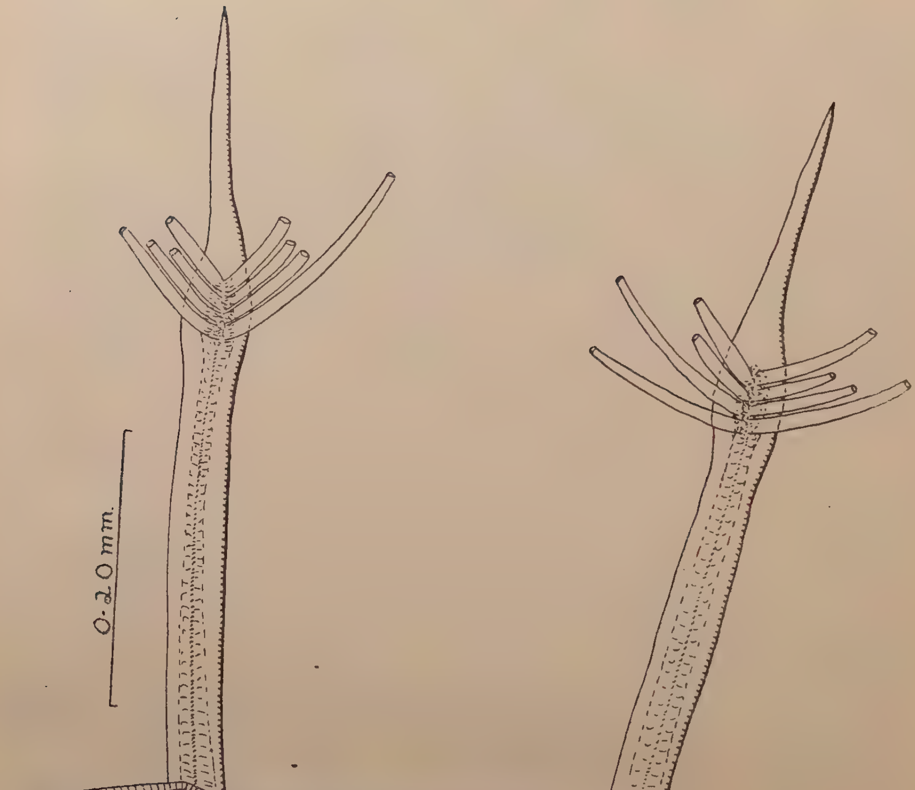
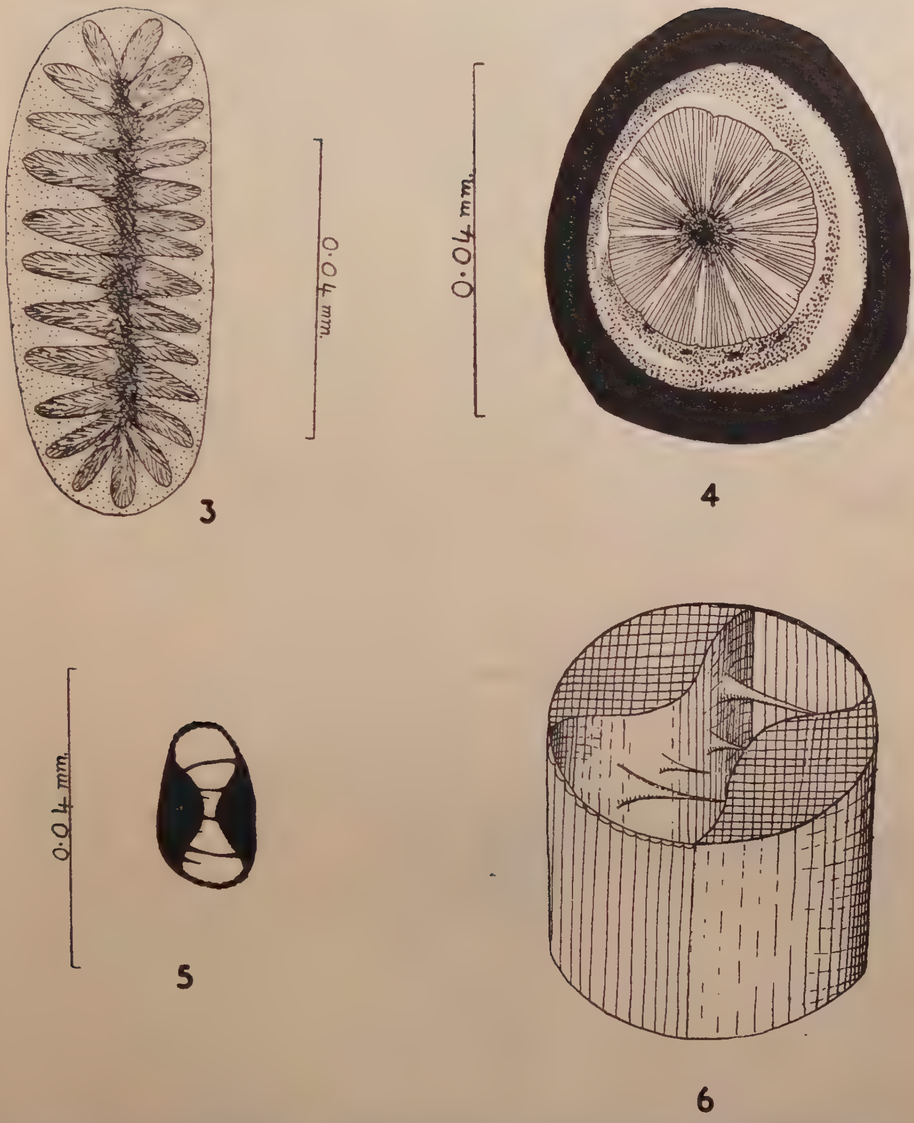


Fig. 2.—Pupa of *Psephenoides volatalis* Champion. Inner ventral view of the left side of the third and fourth abdominal segments illustrating the relation of the tracheae, closing apparatus, spiracular chamber, and gills to each other.



FIGS. 3–6.—Pupa of *Psephenoides volatalis* Champion. (3) Cross section through the spiracular chamber at a point near the closing apparatus. (4) Cross section at basal third of dorsal spine. (5) Cross section though the basal part of one of the cuticular gills. (6) Diagrammatic representation of a portion of the apical half of a cuticular gill.

has a darker staining and more solid mass of felting extending throughout most of its length. The felt chamber is approximately 0·5 mm. long in a pupa 3 mm. long. In relation to the size of the insect, the felt chamber of *P. volatalis* is one of the longest yet described.

Each gill is a tube which is narrowly elliptical at its point of origin (fig. 5) but becomes more circular in cross section towards its distal end. Many of the gills appear to be quite circular in cross section in their distal halves, as shown in fig. 6. Where the gills are distinctly elliptical, it is the long sides that are heavily sclerotised and greatly thickened (fig. 5), whereas the short sides are membranous. The thickened sides are connected to each other by a number of cuticular spines which appear to be irregularly distributed. These spines obviously serve to keep the membranous walls from crumpling by keeping the thickened walls rigidly apart. In each gill examined there were a number of shorter spines which did not join the opposite wall. The thinner or membranous walls are longitudinally striated, and it must be through these walls that the exchange of gases takes place.

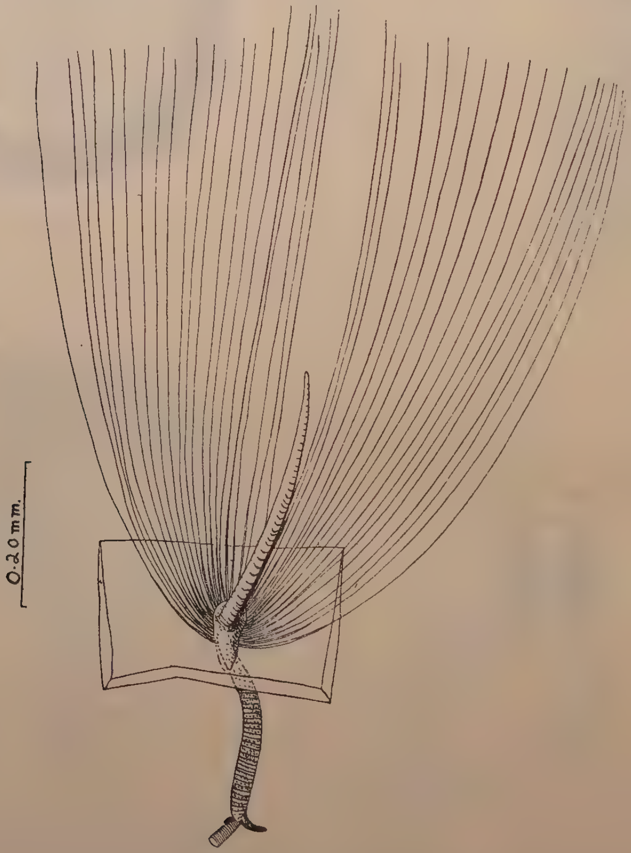


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Fig. 7.—Pupa of *Psephenoides gahani* Champion. Dorsal view of spine and gills of the right side of the third abdominal segment.

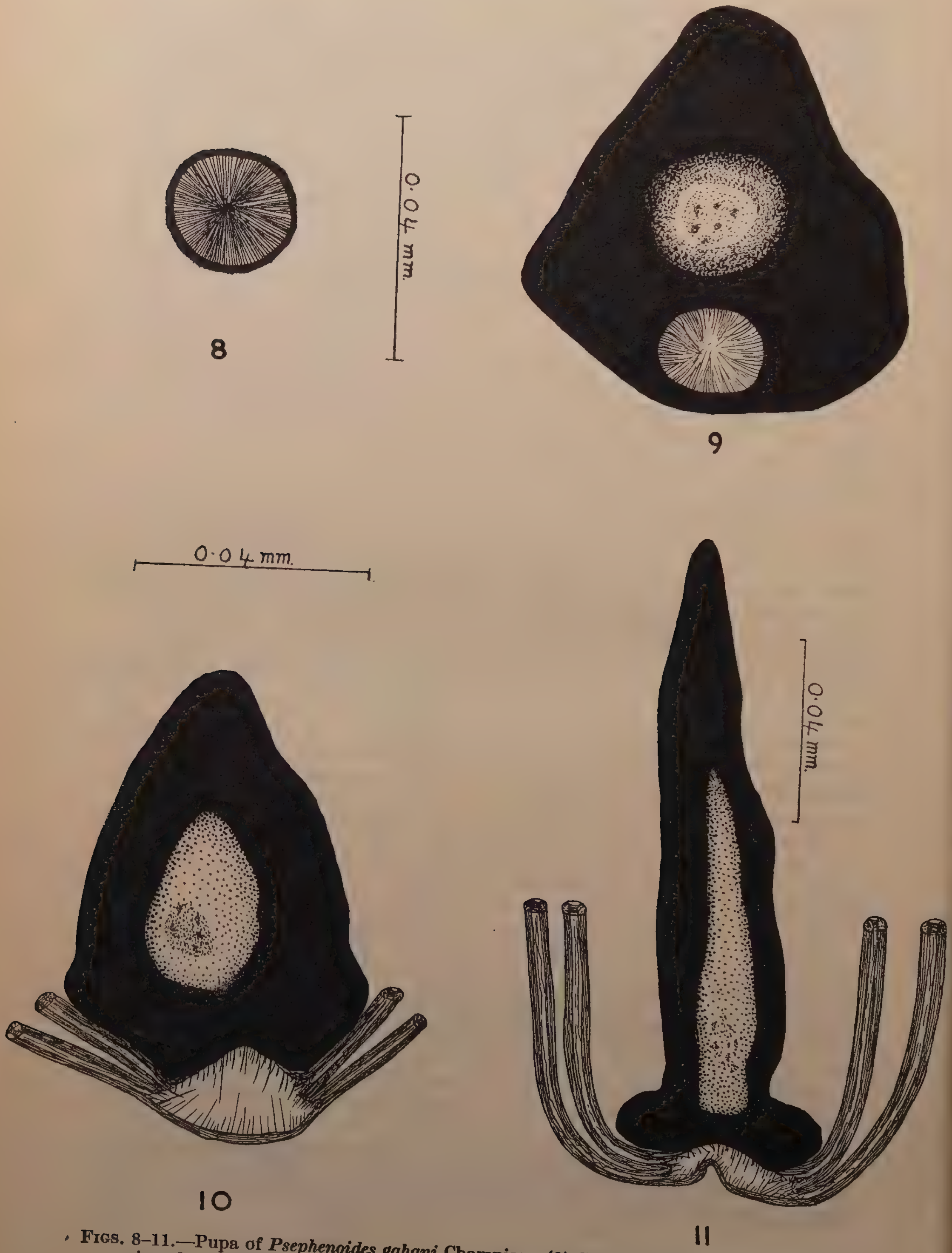
The average number of gills is greater on the anterior than on the posterior segments, which might be expected on general grounds. The surprising thing is that there are no gills on the thorax. According to the segment, the number of gills of five pupae varied as follows : second segment, 8–10; third, 8–10; fourth, 8–10; fifth, 8–10; sixth, 6–10; and seventh, 4–6. The number of gills was not always the same on both sides of the same segment, and some segments had an odd number of gills, but such instances may be due to accidental breakage, which is very difficult to detect. All of the spiracular chambers that were sectioned had an even number of gills.

The general appearance of the gills of *P. gahani* is shown in fig. 7 and pl. 1, fig. 1. The spiracles of the second to seventh abdominal segments are essentially identical. The spiracular chamber does not extend into the dorsal spine, as is the case in *P. volatalis*, but extends very much more deeply into the body. The chamber is approximately 0·30 mm. long in a pupa 3 mm. long. The spiracular chamber is continued under the base of the dorsal spine and ends a short distance laterad from the base of this spine. The felting of the chamber (fig. 8) is very similar to that of *P. volatalis*. The felting of the apical part of the chamber, from which the gills arise, is distinctly less dense than that of the more proximal parts. Eighteen to twenty very long and delicate gills arise from each side of the apical pocket of the spiracular chamber. Only three tufts of gills were counted, and of these two had 40 and the other 36 gills.

The structure of these gills differs somewhat from that of the gills of *P. volatalis*. The basal or proximal part of each gill is narrowly elliptical in cross section. Each of the long sides is formed of four or five stout parallel struts connected to each other by membrane or very thin cuticle. The struts of the two sides meet and are usually fused in the centre, so that each gill has five or six separate compartments (fig. 12). Towards the apex, the number of these struts is reduced, so that, at least in some gills, there are only two struts at the apex. The apical parts of the latter are thus nearly identical to the gills of *P. volatalis*. When preserved specimens are dried, all of the proximal parts of the gills maintain their structure, but at their apices, which are only supported by two longitudinal struts, the struts are sometimes thrown into a spiral around each other.

The proximal portion of the gills of *P. volatalis* consists of two thick and heavily sclerotised walls held rigidly apart by numerous connecting spines, and less than half the circumference of each tube or gill is membranous. The proportion of the tube which is thick and hard decreases distally, so that near the apex the two membranous walls of the tube include more than half of the circumference. When preserved specimens are dried, the proximal part of the gills maintain their structure but the membranous parts are sometimes ruptured apically. The tearing of the membrane is due to the fact that the two thickened walls of the tubes are not equally thick and the slightly unequal contraction brought about by desiccation is sufficient to bend and break the internal connecting spines or rods and cause the thickened walls to spiral around each other.

By analogy with most other insects which do not hibernate as pupae, it seems reasonable to suppose that during more than half of the time spent within the pupal cuticle the beetle will be an adult and the pupal



FIGS. 8–11.—Pupa of *Psephenoides gahani* Champion. (8) Cross section through middle of spiracular chamber. (9) Cross section through base of dorsal spine and spiracular chamber before the point of origin of the gills. (10) Cross section through spiracular chamber to show the point of origin of the cuticular gills. (11) Cross section of the same nearer the apex of the chamber.

cuticle will be only mechanically connected to the adult. This supposition also appears likely from the fact that the great majority of specimens examined were pharate adults and not, properly speaking, pupae although they were collected on several different dates. Exposure of the pupa by a fall in the water level will probably occur more often in the second rather than in the first half of the "pupal" period, so that at this time the drying of the now dead pupal cuticle can be compared directly with the drying of the pupal cuticle of preserved specimens. If this reasoning is correct, it follows that when the pupa or the pharate adult is exposed under natural conditions the gills do not collapse and air can pass through the membranous walls. If the gills do not collapse in the dead cuticle, they are scarcely likely to collapse if exposed above water when the pupal cuticle is connected to the epidermis of the pupa in the first period after shedding the larval skin. Should the tips of the gills have their membranous walls ruptured on exposure under natural conditions—as happens when preserved specimens are dried—the tracheal system would become an open one in the sense that air can be drawn directly into it instead of through the interstices of a membrane. The gills of pupae that are submerged after a period of drying will continue to function as before, and the fine splits in the membrane are not likely to permit the entry of water. The cuticular "felting" of the spiracular chamber would almost certainly prevent the entry of water where a gill may be broken at its base.

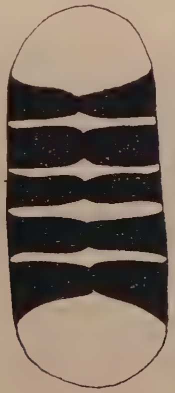


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FIG. 12.—Pupa of *Psephenoides gahani* Champion. A partly diagrammatic illustration of a cross section through the base of a cuticular gill.

That the pupae of *Psephenoides* are adapted to live both in and out of the water seems probable from the structure of their gills. Their remarkably long felt chambers certainly appear to be an adaptation to prevent water loss when the pupae are exposed above the water. In this connection it is of some interest to note that experiments made by Pulikovsky (1927) with the pupae of *Simulium* showed that they survived prolonged exposure out of water, and that out of water the pupal cuticle could be shed by the adults as easily as when the pupae are under water. The gills do not collapse when the pupae are taken from the water. Their walls, which are about 0·1μ thick, remain intact, and, as they are of course permeable to air, the tracheal system of the pupa functions as would an open tracheal system. It should be mentioned here that in nearly all mountainous regions of the world SIMULIDAE are one of the important elements of the insect fauna of rapidly flowing streams.

The function of the dorsal spine associated with each spiracle is not clear to me. It may be said that increases in the number of spines of an insect sometimes have some survival value in making the insect less palatable to predators. In both species the dorsal spines may serve to keep some debris, such as leaves, from close contact with the body and thus tend to keep the water circulating freely over the gills. It appears that one of the functions of the spine of *P. volatalis* is to lift the gills away from the surface of the body into water flowing more rapidly because less impeded by friction against the surface to which the pupa is cemented. It may be imagined that the ancestral gills originated as a few cuticular seta-like outgrowths from the peritreme of the spiracle. In *P. volatalis* the numbers were not materially increased, but, by being carried some distance away from the substrate, their efficiency was increased. In this species the extension of the spiracular chamber in the spine enabled the development of a relatively longer chamber than in species where a great increase in length could only be accomplished either by pushing the tracheal trunks nearer the middle of the body or by convoluting the chamber. In *P. gahani* the tracheal gills probably remain in their original position but their numbers are greatly increased.

ACKNOWLEDGEMENTS.

My best thanks are due to Dr. A. D. Imms, F.R.S., for the drawings of the whole pupa reproduced in the plate and to Mr. S. Prudhoe for preparing sections of the gills of the two species.

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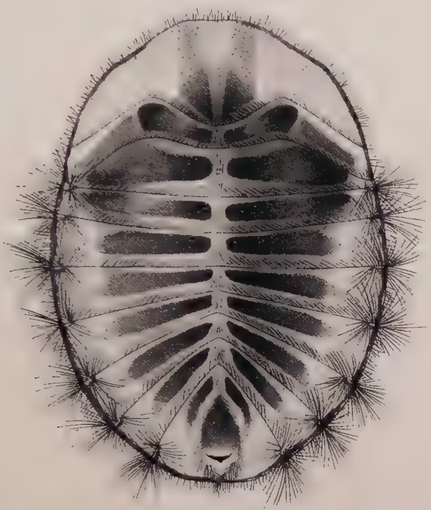
EXPLANATION OF PLATE I.

FIGS. 1–2.—*Psephenoides gahani* Champion. (1) Dorsal view of pupa. (2) Ventral view of pupa.



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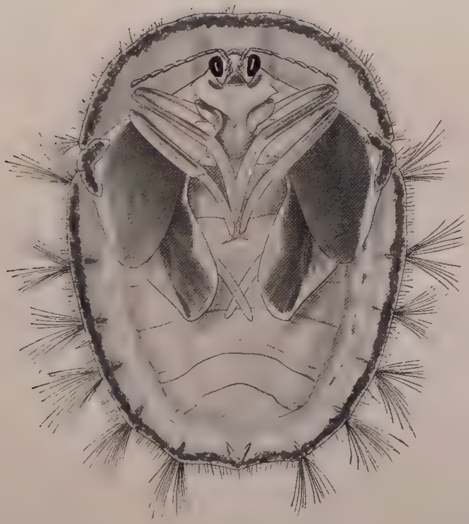

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H. E. Hinton. *Pupa of* Psephenoides gahani *Champion.*

NOTES ON A SPECIES OF EPIPYROPIDAE (LEPIDOPTERA) PARASITIC ON *METAPHAENA* SPECIES (HEMIPTERA : FULGORIDAE) AT AMANI, TANGANYIKA

By T. W. Kirkpatrick, M.A., F.R.E.S.

Since it is believed that this is the second record of Epipyropidae from Africa, the following biological notes, though very incomplete, should be of interest.

I have found the *Epipyropid,* which Mr. W. H. T. Tams of the British Museum (Natural History) has described as *Fulgoraecia cerolestes* sp. n., parasitising two species of *Metaphaena—M. cruentata* Gerstaecker which occurs on the introduced tree *Grevillea robusta,* and *M. militaris* Gerstaecker which I have only seen on a species of *Entandophragma,* a tree indigenous but uncommon in the Amani forest. Most of these observations refer to parasites on *Metaphaena cruentata.*

This Fulgorid occurs in small colonies of from five to twenty adults on the trunks of *Grevillea,* but though there are numerous *Grevillea* in the Amani district, I only know of two such colonies. One of these, at least, has been in existence on the same trees for many years, though it was only early in 1945 that I first noticed the Epipyropid.

I have not been able to find the immature stages of either species of *Metaphaena.* They may live on the upper branches of the trees on which the adults are to be found, but they certainly never occur on the trunks of these trees, nor on other vegetation in the neighbourhood.

In 1945 adults of *M. cruentata* were usually present from February to early June although the number varied from time to time. None was seen during the remainder of the year ; a very few appeared in January, 1946, but they did not become common until April. It was not possible to make frequent or regular observations on the small colony of *M. militaris* on the trunk of an *Entandophragma* in the forest, but a few adults were present from February to September, 1945 : none was then seen until April, 1946, when at first one and later three adults reappeared.

Both species generally remain almost motionless on the tree-trunk. If disturbed they fly away for a short distance, but usually come back to the same tree and often to very nearly the same position on it. I have twice, in April, 1946, seen a pair of (unparasitised) *M. cruentata in copula* on a *Grevillea* trunk. I have not succeeded in keeping adult *Metaphaena* alive in captivity for more than a week or ten days. Such few observations as have been made on the Epipyropid have therefore been under natural conditions. Owing to the sluggish habits of *Metaphaena* it has, however, been possible on two occasions to place a first-instar larva of the Epipyropid on to a healthy specimen of *M. cruentata* and observe its development until pupation.

Life history of *Fulgoraecia cerolestes* Tams.

The first-instar larva is exceedingly active although, like so many migratory first stage parasitic larvae of different orders of insects, it frequently stops walking, erects the anterior part of its body and waves itself from side to side. In the laboratory they only survive for two or three days—a very few for five days—in the absence of a host. Presumably they find a host by random searching. Having found a host the larva takes up its position on the dorsum of the abdomen with its head directed towards the posterior end of the host.

There has apparently been some doubt as to the method of feeding of Epipyropidae, some observers asserting that they puncture the integument of the host and others that they feed on the wax secreted by them (Clausen, 1940). This species appears to feed on the wax, the production of which seems to be stimulated by the presence of the parasite, for unparasitised adult *Metaphaena* secrete very little wax. Although there are no indications that the integument is punctured, yet a parasitised host apparently always dies within twenty-four hours of the full-grown larva of *F. cerolestes* leaving it. Except for this, nothing is known of the effects of the parasite on its host, but it is suggested that the fertility of the *Metaphaena* may be impaired if not destroyed.

Two larvae have several times been found on one host and once three, but only one from each host has ever become full-grown and pupated. I do not know how many parasitic larval instars there are: exuviae of two quite different sizes have been found still adhering to the host, but it is quite likely that there are more than three parasitic instars. The developmental period, from attachment of the first-instar larva until the full-grown larva leaves the host, was 28–30 days in two instances observed during April, 1946.

As soon as the full-grown larva has left the host it spins a white waxy cocoon on the tree-trunk. Observed durations of the pupal period varied between 18 days at an average temperature of about 24° C. to 25 days at about 22° C.

When the adult moth emerges the empty pupa case is left protruding from the cocoon. The female remains on or close to the cocoon and pairing can occur on the day of emergence. It lasts for 10–15 minutes and may be repeated later on the same day. Oviposition starts a few hours after copulation and almost all the eggs are laid within the next 24 hours. Of two fertilised females kept in the laboratory one laid about 2,000 eggs and the other nearly 3,000. The last 200–300 eggs laid by each of these females were paler in colour than the rest and were apparently infertile. Although these females lived for about two weeks after the last egg was laid and to one of them a fresh male was introduced, no further copulation was observed.

One unfertilised female was kept in the laboratory. Three days after emergence this laid some 300 eggs only, none of which hatched. Some species of Epipyropidae, it should be noted, are parthenogenetic (Perkins, 1905).

The eggs are normally laid on the trunk of the tree, in batches of

200–400, within about one foot of the cocoon from which the female emerged.

Since a female lays all its eggs within about twenty-four hours, immediately after fertilisation, it appears remarkable that they should not hatch almost simultaneously but over a period which is known to extend over a year, and may possibly prove to be much longer.

Table 1 shows the dates of hatching of the eggs laid by two females in glass-bottomed "pill-boxes" in the laboratory. The first was fertilised on 25.iv.45 and laid about 2,000 eggs on 25–26.iv.45 ; the second was fertilised on 4.v.45 and laid about 3,000 eggs on 4–5.v.45. Both lots started to hatch on 15.viii.45 and continued fairly regularly at an average of two to three a day each until 19.vi.46, when I left Amani. Dr. D. W. Duthie is kindly continuing the observations for me and I have recently heard from him that they are still (on 8.viii.46) continuing to hatch. There were a few days on which none hatched and the greatest number on any one day from one batch was ten, but the comparatively slight variations in the number hatching during ten-day periods cannot apparently be correlated with changes in temperature or humidity. Table 2 shows the dates of hatchings from a batch of 175 eggs taken from the trunk of an *Entandophragma* on 26.xi.45 and brought into the laboratory : the date on which these were laid is not known.

TABLE I.

Dates of eclosion of eggs of *E. cerolestes* laid in laboratory.

Ten-day period ending	(*a*) *Eggs* (*about* 2,000) *laid* 25–26.iv.45	(*b*) *Eggs* (*about* 3,000) *laid* 4–5.v.45
24.viii.45	6	25
3.ix.45	8	21
13.ix.45	16	31
23.ix.45	12	16
3.x.45	16	10
13.x.45	15	13
23.x.45	22	22
2.xi.45	22	10
12.xi.45	10	26
22.xi.45	23	28
2.xii.45.	12	19
12.xii.45	18	25
22.xii.45	19	30
1.i.46	21	36
11.i.46	26	26
21.i.46	14	28
31.i.46	14	27
10.ii.46	26	20
20.ii.46	19	23
2.iii.46	16	16
12.iii.46	25	14
22.iii.46	18	9
1.iv.46	23	12
11.iv.46	27	24
21.iv.46	27	22
1.v.46	27	24
11.v.46	24	31
21.v.46	24	21
31.v.46	24	31
10.vi.46	28	31
Total number hatched up to 10.vi.46	582	671

TABLE II.

Dates of eclosion of Epipyropid eggs (about 175) laid on an unknown date on *Entandophragma* sp. and brought to laboratory on 26.xi.45.

Date	*Number hatching*	*Date*	*Number hatching*
26.xi.45	1	18.ii.46	1
28.xi.45	1	20.ii.46	1
30.xi.45	1	21.ii.46	1
1.xii.45	1	25.ii.46	1
5.xii.45	1	6.iii.46	8
11.xii.45	1	11.iii.46	1
13.xii.45	1	21.iii.46	1
15.xii.45	1	23.iii.46	1
17.xii.45	2	24.iii.46	1
21.xii.45	1	26.iii.46	1
23.xii.45	1	30.iii.46	1
25.xii.45	1	1.iv.46	1
27.xii.45	1	2.iv.46	1
4.i.46	1	4.iv.46	1
5.i.46	1	5.iv.46	1
6.i.46	1	7.iv.46	1
9.i.46	1	9.iv.46	2
10.i.46	2	12.iv.46	1
17.i.46	1	14.iv.46	1
18.i.46	1	20.iv.46	1
31.i.46	1	18.v.46	1
1.ii.46	1	21.v.46	1
9.ii.46	1	22.v.46	1
11.ii.46	1	24.v.46	1
12.ii.46	1	14.vi.46	1
14.ii.46	2	16.vi.46	1

It is probable that this extended hatching of the eggs tends to ensure the survival of the species, for if all the eggs laid by one female were to hatch together, this might occur when no adult *Metaphaena* happened to be present. Conversely, if it were to happen at a time when the whole *Metaphaena* population was congregated on the tree trunks, it would result in excessive parasitism and, if this parasite does in fact render its host sterile, the host would become extinct.

It is, however, difficult to imagine the physiological mechanism by which a large number of eggs, all fertilised on one day and laid on the following day, and kept in the same environment, should hatch, a few on almost every day, over a period lasting for a year or possibly more.

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